

Learning Ocean Science Through Ocean Exploration

A Curriculum for Grades 6–12

Editor: Valerie Chase, Ph.D.

EXPLORE 

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– Tanya Podchaski

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– Mel Goodwin, Ph.D.

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– Mel Goodwin, Ph.D.

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– Tanya Podchaski

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– Rachel McEvers

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– Mel Goodwin, Ph.D.

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– Rachel McEvers

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– Barbara Eager

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– Mel Goodwin, Ph.D.

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Maps and data from the Hawaiian Islands enable students to draw inferences about the process and sequence of the island chain's development.

– Mel Goodwin, Ph.D.

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While most ocean explorations focus on the deep-sea floor and its benthic ecosystems, there are also scientists on board many expeditions who are interested in the organisms that live in open water—both pelagic swimmers and plankton. This section examines the physical factors that distinguish vertical zones in the ocean.

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Students use glasses that let them experience the relationship between light and depth. They also observe what happens to colors at depth. *– Stacia Fletcher*

LP 14 Light at the Bottom of the Deep, Dark Ocean 100
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The creation of life-sustaining carbon compounds from inorganic components is the basis of life on Earth. The primary production of biological molecules is largely accomplished by photosynthesis, but chemosynthetic bacteria sustain several unique ocean ecosystems. These bacteria use energy from inorganic chemical metabolism to power the production of organic molecules as sources of energy and food.

LP 15 Being Productive in the Arctic Ocean 109
Students use data cards to assemble information about the physical characteristics of the Arctic environment that control photosynthesis in the far northern ocean. *– Mel Goodwin, Ph.D.*

LP 16 Chemosynthesis for the Classroom 120
Bacteria are amazing. In this comparison of bacterial communities grown in the light and in the dark,

students witness the development of bacterial communities that use chemosynthesis to sustain a model ecosystem just as chemosynthetic bacteria support entire deep hydrothermal vent communities.

– Mel Goodwin, Ph.D.

LP 17 Biochemistry Detectives..... 123

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– Mel Goodwin, Ph.D.

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Only a few unique species are the focus of this section. They were chosen because they are novel and strange. Deep vent tubeworms were totally unknown before 1977. This section also considers the unique natural chemical properties of some species that may make them a source of useful human products in the future.

LP 18 Let's Make a Tubeworm!..... 133

Start your students' tubeworm studies by making models of this strange organism.

– Mel Goodwin, Ph.D.

LP 19 This Old Tubeworm..... 136

Your students will use real data to study the ages of cold seep tubeworms—worms that may live longer than humans!

– Mel Goodwin, Ph.D.

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Students use deep vent studies as a source for “in-venting” invertebrates that are adapted to deep hydrothermal vent conditions.

– Robin Sheek and Donna Ouzts

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Marine invertebrates, especially those living at-

tached to surfaces, are especially subject to competition for space and exposed to predation. There has been selection among them for chemicals that are biologically-active against other species that reduce competition for space or discourage predators from eating them. These chemicals may be developed into commercial products some day. – Mel Goodwin, Ph.D.

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Each ocean exploration expedition asks questions about the composition and structure of deep-sea communities. These communities change over time. Deciding how to sample them in the limited time available is a challenge for ocean scientists. The scientists are seeking to describe the distribution and abundance of deep-sea creatures around the geologic features studied.

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Students use authentic data from hydrothermal vents on the Galapagos Rift to ask questions about the distribution of species around a vent in relation to physical conditions. They also address questions about the development and changes in the vent community over time.

– Stacia Fletcher

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Students use data to answer questions about the development and relationships of communities on a chain of Alaskan seamounts. Conservation issues related to protecting biological diversity are addressed.

– Mel Goodwin Ph.D.

LP 24 Would You Like a Sample?..... 165

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– Mel Goodwin, Ph.D.

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While ocean exploration is about looking forward, many expeditions included some aspect of potential or past human impacts on the ecosystems studied. Here are two.

LP 25 Seals, Corals and Dollars 176

Students use information from web sites and other sources as the basis of their arguments about potential commercial exploitation of deep-water corals. Harvesting is complicated by the presence of an endangered marine mammal—the Hawaiian monk seal.

– Mel Goodwin, Ph.D.

LP 26 Polar Bear Panic! 179

Students manipulate and graph three different data sets related to ice cover in the Arctic. They infer changes over time and speculate on potential impact of long-term changes on polar bears.

– Mel Goodwin, Ph.D.



Introduction

By Captain Craig N. McLean

Director, Office of Ocean Exploration

National Oceanic and Atmospheric Administration

NOAA is very pleased to bring you this curriculum, and to provide you with useful tools for ocean education. The ocean is a fascinating place. The oceans bring life to our Earth, providing the world with oxygen, renewable resources, and an amazing variety of marine life, though much of it unseen. An exciting world exists beneath the sea, filled with many secrets that are slowly being revealed.

The material in this curriculum provides an opportunity for the same kind of excitement and discovery that our scientists experience during their many journeys to the unknown parts of the sea, and an opportunity to convey that excitement with structured learning experiences. As you will see, while the accomplishments of science are many, there is still much about the oceans that we do not know. Considering that less than five percent of the world's oceans have been truly explored, by working with these ocean science materials, you will be participating in the discovery of a great frontier—the last remaining frontier on Earth.

When NOAA began its program in Ocean Exploration, it determined that it should allocate at least ten percent of its resources to education and outreach. As a result, professional educators participate in discovery missions, in curriculum planning and preparation of mission materials, including the work in this curriculum, and in going to sea. Not everyone can make the actual journey, but by joining NOAA through the material in this curriculum and by visiting our award-winning web site, <http://oceanexplorer.noaa.gov>, you can be part of the amazing world of ocean exploration.

It is very important to provide our young people with an education and awareness about the oceans today so that they can make informed decisions about their world tomorrow. Your role in accomplishing that mission is perhaps the most important. Within the reach of all educators are the scientists and engineers of tomorrow, the future technological strength of our Nation. And within your reach is the power and importance of influencing young minds of all ages about the oceans. That is an important opportunity, and an amazing responsibility.

Thank you for taking the journey with NOAA, at sea for the purpose of discovery, and in the world of education to help change the way America thinks about the ocean. Your job is most important. I hope we can make it a little easier.

Introduction and Guide to the Use of this Curriculum

When the National Oceanic and Atmospheric Administration (NOAA) established its Ocean Exploration Program, the Agency did something unusual for a program focused on scientific ocean discovery as it launched multidisciplinary voyages of discovery to little-known or unknown ocean regions. Following the recommendations put forth in the President's Panel on Ocean Exploration Report entitled *Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration*, the Agency formed partnerships and collaborations among scientists, educators, and others to develop educational and outreach resources tied to these voyages of discovery to reach out in new ways to share ocean discoveries with teachers, students and the general public. Through its Ocean Explorer (OE) web site at <http://oceanexplorer.noaa.gov>, this curriculum, the supporting professional development for teachers, and strong partnerships, NOAA is embracing unique opportunities to engage explorers of all ages as it takes journeys into a world that few have ever seen.

The OE web site provides an educational opportunity to anyone wanting to learn about, discover, and virtually explore the ocean realm. Near-real time exchanges with scientists and educators on the voyages of discovery are brought to the web site through educators who are skilled interpreters of information as well as scientists who communicate their enthusiasm and expertise directly to you. Content and media-rich, the web site contains thousands of pages of essays, videos, and images from NOAA's Ocean Exploration voyages of discovery, covering an extensive range of ocean exploration topics. Most of these voyages of discovery have grade-level specific student classroom lesson plans that are posted along with them. Classroom teachers and other educators use these activities to sup-

**The National Oceanic and
Atmospheric Administration's
(NOAA's) Commitment to
Share Ocean Exploration and
Discovery through Education**

**NOAA Ocean Explorer
Web Site**

The Ocean Explorer Web Site Companion CD-ROM

port learning ocean science through ocean exploration. These lessons use the National Science Education Standards (Standards) as a guide and the Standards are referenced on each lesson plan.

The OE web site continues to grow each year as new voyages of discovery are added and previous ones are maintained. Since many classrooms are limited in their access to the Internet, NOAA has developed an Ocean Explorer web site companion CD that contains, as of this writing, the entire Ocean Explorer web site through January 2003. The CD operates just like the OE web site, letting students experience the same technology. This OE curriculum is designed to be used in conjunction with the Ocean Explorer web site and/or CD. It is greatly enhanced when students have access to additional ocean science sites on the Internet that are referenced with each activity.

What is *Learning Ocean Science through Ocean Exploration?*

Good science curriculum has scope and sequence. It is focused on a set of grade levels and is organized in such a way that following it supports student learning in a logical developmental sequence in which each part builds on what came before. There are over 100 ocean science activities posted on the OE web site, organized independently by voyage of discovery. *Learning Ocean Science through Ocean Exploration* takes activities selected from the voyages of discovery and presents them in a comprehensive scope and sequence through subject area categories that cut cross the individual voyages of discovery. This curriculum was developed to take advantage of the tremendous resources residing on the Ocean Explorer web site and to present lessons in a manner more conducive to teaching and learning in both formal and informal education settings.

Building *Learning Ocean Science through Ocean Exploration*

In order to build this curriculum, the editor assembled, evaluated and organized by theme all lesson plans posted as part of the 2001 and 2002 NOAA Ocean Exploration

field seasons. Naturally, there was overlap in content among the lesson plans since there was similarity in science focus on the expeditions—seamounts have similar origins, for example. About one third of the lessons were selected for inclusion in this curriculum. Since students show wide ranges of abilities in middle and high school, we did not narrow the grade range suggested beyond secondary. An advanced group of eight graders who have had pre-algebra may perform at the same level as a general science class of high school seniors. Secondary teachers have the technical scientific background and developmental knowledge needed to select from among these activities. The Table of Contents indicates the original author of each exercise. All of the original lessons from the web site that were selected to be included in this curriculum were edited, some more extensively than others.

The themes were arranged in an order that progresses from physical science through earth science to biological and environmental science—ocean sciences include all of these content areas. A content introduction was written for each of the nine themes identified. Each Section Introduction may have text written by one or more of the original lesson plan authors as well as text added by the editor. Each lesson plan on the Ocean Explorer web site assumes that the reader might use that lesson independently of other supporting materials, and so by design, there is a good deal of redundancy in content background supplied within lesson plans developed for and grouped within each voyage of discovery. Here, the activities have been edited, and the general content merged into the Section Introductions.

There is slightly more proportional emphasis on physical and earth sciences in this curriculum than among the lesson plans found on the Ocean Explorer web site. As mentioned above, only about one-third of the 2001 and 2002 lesson plans were used in the development of the *Learning Ocean Science through Ocean Exploration*

Additional Lesson Plans

Future Opportunities

curriculum. A listing of all the Ocean Explorer activities that relate to the topic of a particular content section can be found at the end of that content section.

Look for Ocean Exploration Professional Development offerings, including courses offered at annual conferences of the National Science Teachers Association (NSTA), at regional and state science teachers' association conferences, as well as in partnership with science centers and aquariums and the National Marine Educators Association conferences. Check the Ocean Explorer web site frequently for new professional development opportunities and new postings of Ocean Exploration voyages of discovery.

Comprehensive Ocean Sciences

This is not a complete ocean science curriculum since it is built around a set of explorations. If you are a teacher wishing to develop a comprehensive ocean science course, you will want to add a good bit more physical science and atmospheric science as well as coastal processes and perhaps an introduction to ocean organisms and their taxonomy. For example, you will not find waves and tides here nor is there intertidal zonation since NOAA Ocean Exploration efforts thus far have focused largely on the deep ocean. Additional web sites referenced in each lesson plan offer additional ocean science activities to complete your ocean science course.

What is unique here is the combination of the Ocean Explorer web site and/or CD and the lessons presented in *Learning Ocean Science through Ocean Exploration* since they are designed to work together. Both give teachers and students a direct connection to the scientists whose work they are modeling in the classroom and a direct connection to the exciting new discoveries on each NOAA Ocean Exploration voyage of discovery.

*Editor: Valerie Chase, Ph.D.
Retired in 2002, after almost 23 years at the
National Aquarium in Baltimore*